

Attachment 2. Formulas Used to Derive Un-ionized Ammonia Fractions and USEPA Ammonia Criteria

Calculating Salinity (ppt) from Electrical Conductivity

$$S = S_{PSS} - \frac{0.0080}{1 + 1.5 \times X + X^2} - \frac{0.0005 \times f(T)}{1 + Y^{0.5} + Y^{1.5}}$$

where,

S = salinity (ppt) (using extension of Practical Salinity Scale to low salinities [0-40])

S_{PSS} = Salinity, using Practical Salinity Scale

$$S_{PSS} = 0.0080 - 0.1692 \times R^{0.5} + 25.3851 \times R + 14.0941 \times R^{1.5} - 7.0261 \times R^2 + 2.7081 \times R^{2.5} + \Delta S$$

$$\Delta S = \left[\frac{T - 15}{1 + 0.0162(T - 15)} \right] \times \left(0.0005 - 0.0056 \times R^{0.5} - 0.0066 \times R - 0.0375 \times R^{1.5} + 0.0636 \times R^2 - 0.0144 \times R^{2.5} \right)$$

$$f(T) = \frac{T - 15}{1 + 0.0162(T - 15)}$$

$$X = 400 \times R$$

$$Y = 100 \times R$$

T = temperature (°C)

$$R = \frac{EC_s}{EC_R}$$

EC_s = electrical conductivity of sample ($\mu\text{S}/\text{cm}$)

EC_R = electrical conductivity of seawater reference (58,670 $\mu\text{S}/\text{cm}$)

SALTWATER FORMULAS

Un-ionized Ammonia in Saltwater

$$f_{NH_3} = \frac{1}{1 + 10^{\left[pK_a + 0.0324(298 - T) + \frac{(0.0415)P}{T} - pH \right]}}$$

where,

f_{NH_3} = fraction of un-ionized ammonia

$$I = \frac{19.9273 \times S}{1000 - 1.005109 \times S} \quad (\text{from EPA 1989, formula 5, p. 2})^1$$

$$pK_a = 9.245 + 0.116 \times I$$

S = salinity (ppt)

T = temperature (°K)

P = pressure (assumed to be 1 atm)

Total Ammonia Saltwater Criterion Maximum Concentration (USEPA 1989, p. 27)

$$C_{CMC} = \frac{0.233}{f_{NH_3}} \quad (\text{in mg/L as N})$$

Total Ammonia Saltwater Criterion Continuous Concentration (USEPA 1989, p. 16, 27)

$$C_{CCC} = \frac{0.035}{f_{NH_3}} \quad (\text{in mg/L as N})$$

FRESHWATER FORMULAS

Un-ionized Ammonia in Freshwater (USEPA 1999, p. 2)

$$f_{NH_3} = \frac{1}{1 + 10^{pK - pH}}$$

where,

$$pK = 0.09018 + \frac{2729.92}{273.2 + T}$$

T = temperature (°C)

f_{NH_3} = fraction of un-ionized ammonia

Total Ammonia Freshwater Criterion Maximum Concentration when salmonid fish are present (USEPA 1999, p. 83)

$$C_{CMC} = \frac{0.275}{1 + 10^{7.204 - pH}} + \frac{39.0}{1 + 10^{pH - 7.204}} \quad (\text{in mg N/L})$$

Total Ammonia Freshwater Criterion Continuous Concentration when early life stages of fish are present (USEPA 1999, p. 83)

$$C_{CCC} = \left(\frac{0.0577}{1 + 10^{7.688 - pH}} + \frac{2.487}{1 + 10^{pH - 7.688}} \right) \times \text{MIN} \left(2.85, 1.45 \times 10^{0.028(25 - T)} \right) \quad (\text{in mg N/L})$$